XXI. *New Electrical Experiments and Obſervations; with an Improvement of Mr.* Canton's *Electrometer. By Mr.* Tiberius Cavallo, *in a Letter to Mr.* Henly, *F. R. S.*

Iſlington,
February 8, 1777.

DEAR SIR,

Read March 13, 1777.

TOGETHER with this letter I ſend you an account of ſome electrical experiments I have lately made, and moſt of which have been ſucceſsfully repeated in your preſence. As you did me the honour to mention, in your laſt paper to the Royal Society, ſome remarks I had made on Mr. VOLTA's machine, I hope you will farther oblige me by preſenting this account to that learned Body, if you think it contains any thing deſerving the attention of the curious.

I am, &c.

Experiments on Mr. VOLTA'S *plates, commonly called a machine for exhibiting perpetual electricity.*

THE following experiments, which ſhew how both ſides of an electric plate are affected in different circumſtances, were principally made with a plate which meaſured ſix inches and a quarter in diameter, and which conſiſted of a circular piece of thick glaſs coated on one ſide with ſealing-wax(a).

If, after having excited the ſealing-wax, I lay the plate with the wax upon the table, and the glaſs uppermoſt, that is, contrary to the common method; then, on making the uſual experiment of putting the metal plate on it, and taking the ſpark, &c. I obſerve it to be attended with the contrary electricity; that is, if I lay the metal plate upon the electric one, and, while in that ſituation, touch it with an inſulated body, that body acquires the poſitive

(a) Having conſtructed ſeveral of thoſe plates, with a view to diſcover which ſubſtance would anſwer the beſt for coating the glaſs plate, I obſerved that the eaſieſt to be made, and the ſtrongeſt in power, are thoſe made of the ſecond ſort of ſealing-wax. It is remarkable, that ſometimes they will not act well at firſt, but they may be rendered very good by ſcraping with the edge of a knife their ſhining or gloſſy ſurface. This ſeems analogous to the well-known property of glaſs, which is, that new cylinders or globes made for electrical purpoſes are often very bad electrics at firſt, but that they improve by being worked, that is, by having their ſurface a little worn.

poſitive electricity, and the metallic removed from the electric plate appears to be negative.

This experiment, I find, anſwers in the ſame manner if an electric plate be uſed which has the ſealing-wax coating on both ſides; for, whichever ſide of this is excited, it will act like the waxed ſide of the above deſcribed plate, that is, will render the metal plate ſet on it poſitive, and the oppoſite ſide will render it negative.

If, inſtead of laying the electric plate upon the table, it be placed upon an electric ſtand ſo as to be accurately inſulated, then the metal plate ſet on it acquires ſo little electricity that it can only be diſcovered with an electrometer; which ſhews, that the electricity of this plate will not be conſpicuous on one ſide of it, if the oppoſite ſide be not at liberty either to part with, or acquire more of, the electric fluid. In conſequence of this experiment, and in order to aſcertain how the oppoſite ſides of the electric plate would be affected in different circumſtances, I made the following experiments.

Upon an electric ſtand I placed a circular tin plate, nearly ſix inches in diameter, which by a ſlender wire communicated with an electrometer of pith-balls, which was alſo inſulated; I then placed the excited electric plate of ſix inches and a quarter diameter upon the tin plate, with the wax uppermoſt, and on removing my hand from

from it, the electrometer which communicated with the tin plate, that is, with the under ſide of the electric plate, immediately opened with negative electricity. If by touching the electrometer I take that electricity off, the electrometer will not afterwards diverge. But if now, or when the electrometer diverges, I preſent my hand open, or any other uninſulated conductor, at about one or two inches over the electric plate, without touching it, then the pith-balls diverge; or, if they diverged before, they come together, and immediately diverge again with poſitive electricity.—Remove the hand, and the balls come together; approach the hand, and they diverge, and ſo on.

If while the pith-balls diverge with negative electricity, I put the metal plate upon the wax, the balls approach each other for a little time, but ſoon open again with the ſame, that is with negative electricity.

If, whilſt the metallic lies upon the electric plate, I touch the former, the electrometer immediately diverges with poſitive electricity, which if by touching the electrometer I take off, the electrometer continues without divergence. I touch the metal again, and the electrometer opens again; and ſo on for a conſiderable number of times, until the metal plate has acquired its full charge. On taking now the metal plate up, the electrometer inſtantly diverges with ſtrong negative electricity.

I repeated the above experiments with this only difference in the diſpoſition of the apparatus: I put the electric plate with the excited ſealing-wax upon the circular tin-plate, and the glaſs uppermoſt: and the difference in the reſult was, that where the electricity was poſitive in the former diſpoſition of the apparatus, it now became negative, and *vice verſa*; except that, when I firſt lay the electric plate upon the tin plate, the electrometer diverged with negative electricity as well in this as in the other diſpoſition of the apparatus.

All the above experiments have been repeated with an electric plate, which, beſides the ſealing-wax coating on one ſide, had a ſtrong coat of varniſh on the other; and their reſult has been ſimilar to thoſe when the above deſcribed plate was uſed.

Experiments on colours.

Having accidentally obſerved that an electric ſhock, ſent over the ſurface of a card, marked a black ſtroke upon a red ſpot on the card, I was from this induced to try what would be the effect of ſending ſhocks over cards painted with different water colours. Accordingly

I painted ſeveral cards with almoſt every colour I had, and ſent ſhocks over them when they were very dry: the effects were as follows(b):

Vermillion was marked with a ſtrong black track, about one-tenth of an inch wide.

Carmine received a faint and ſlender impreſſion, of a purple colour.

Verdigreaſe was ſhaken off from the ſurface of the card.

White lead was marked with a ſtrong black track, not ſo broad as that on vermillion.

Red lead was marked with a faint mark much like carmine.

The other colours I tried were, orpiment, gamboge, ſap-green, red ink, ultramarine, Pruſſian blue, and a few others, which were compounds of the above, but they received no impreſſion.

It having been inſinuated, that the ſtrong black mark, which vermillion receives from the electric ſhock, might poſſibly be owing to the great quantity of ſulphur contained in that mineral, I was induced to make the following experiment. I mixed together equal quantities of orpiment and flower of ſulphur, and with this mixture, by the help, as uſual, of very diluted gum-water, I painted a card; but the electric ſhock ſent over this left not the leaſt impreſſion.

(b) The force employed was the full charge of one foot and a half of coated glaſs.

Deſirous of carrying this inveſtigation on colours a little farther, I procured ſome pieces of paper painted on both ſides with oil colours(c), and ſending the charge of two feet of coated glaſs over each of them, I obſerved that the pieces of paper painted with lamp-black, Pruſſian blue, vermillion, and purple brown, were torn by the exploſion; but white lead, Naples yellow, Engliſh ochre, and verdigreaſe, remained unhurt.

The ſame ſhock ſent over a piece of paper, painted very thick with lamp-black and oil, left not the leaſt impreſſion. I ſent the ſhock alſo over a piece of paper, unequally painted with purple-brown, and the paper was torn where the paint laid very thin, but remained unhurt where the paint was evidently thicker.

Having repeated thoſe experiments ſeveral times, and with ſome little variation, they were attended with different effects; however, they all ſeem to point out the following propoſition.

I. A coat of oil-paint over any ſubſtance, defends it from the effects of ſuch an electric ſhock as would otherwiſe injure it; but by no means defends it from the force of every electric ſhock that can be given. II. No one colour ſeems preferable to the others, if they be equal in ſubſtance, and equally well mixed with oil; but a thick coating does certainly afford a better defence than a thinner one.

(c) The colours were mixed with linſeed oil.

By rubbing the above mentioned pieces of paper, I find that the paper painted with lamp-black and oil is more eaſily excited, and acquires a ſtronger electricity than the papers painted with the other colours; and perhaps on this account it may be, that lamp-black and oil might reſiſt the ſhock ſomewhat better than the other paints.

It is remarkable, that vermillion receives the black impreſſion, when painted with oil, nearly as well as when painted with water. The paper painted with white lead and oil receives alſo a black mark, but its nature is very particular. The track, when firſt made, is almoſt as dark as that marked on white lead painted with water; but it gradually loſes its blackneſs, and in about two hours after it appears without any darkneſs, and when the painted paper is laid in a proper light appears only marked with a colourleſs track, as if made by a finger-nail.

Promiſcuous Experiments.

Conſidering what a ſtrong ſpark is obtained from the metal plate belonging to Mr. VOLTA's machine, when not the leaſt ſpark can be obtained from the electric plate itſelf, I was naturally induced to make uſe of the above mentioned metallic plate in diſcovering the electricity of very weak electrics, which otherwiſe would be either inobſervable, or ſo little as not to permit its quality to be aſcertained. Accordingly, by the uſe of this plate, I obtain a very ſenſible electricity from the hairs of my legs and of my head, or the head of almoſt any other perſon, when ſtroaked.

In this manner I obtain ſo ſtrong ſparks from the back of a cat, a hare's ſkin, a rabbit's ſkin, a piece of paper, or a piece of new flannel, that I can preſently charge a coated phial with either of thoſe, and ſo ſtrongly as to pierce a hole through a card with its diſcharge.

I have often obſerved, that, when ſtroaking a cat with one hand I hold it with the other, I feel frequent ſmart pricklings on different parts of that hand which holds the animal. In theſe circumſtances very pungent ſparks may be drawn from the tips of the ears of the cat.

Smooth glaſs rubbed with a rabbit's ſkin, dry and warm, acquires, I find, the negative electricity; but if the ſkin is cold, the glaſs is excited poſitively.

New white flannel has alſo ſuch ſtrong electric power, that ſometimes I have excited ſmooth glaſs negatively with it.

Conſidering the ſtrong electric power of new white flannel, I thought that a piece of it rolled round the globe of an electrical machine would perhaps give a ſtronger electricity on the prime conductor than the glaſs itſelf. In order to try the truth of my ſuppoſition, I tied a large piece of flannel dry and warm round the globe of the machine; and for a rubber I applied the palm of my hand, then turned the winch, firſt ſlowly, and afterwards briſkly; but, contrary to my expectation, I obſerved that the electricity at the prime conductor, although poſitive, was ſo weak, that the index of your electrometer was not moved. Surpriſed at this event, I reſolved to take off the apparatus; but I was more ſurpriſed when, on removing the flannel from the globe, the former appeared ſo ſtrongly poſitive, that it darted ſeveral ſparks to my arm and other contiguous bodies; and the latter remained ſo ſtrongly negative, that your electrometer upon the prime conductor inſtantly elevated its index to about 45°. I repeated this experiment ſeveral times, and the effect was always the ſame. The electricity of the flannel and of the glaſs, therefore, balanced each other.

Having had occaſion to coat a ten-ounce phial, I ſtuck the inſide coating, which was of braſs filings, with varniſh, agreeable to the directions given by ſome writers on electricity. This phial remained about a week unuſed; but it happened, that, whilſt I was charging and diſcharging it for ſome experiments, I obſerved that on making a diſcharge it exploded with a greater noiſe than uſual, the cork with the wire being at the ſame time blown out of the neck of it. Being intent upon the main experiments in hand, I omitted to examine the phenomenon of the phial. I replaced the cork on it, and went on charging and diſcharging it again; but it had not been charged above three or four times more, when I obſerved that, on making a diſcharge, the varniſh that ſtuck to the braſs filings was in a flame, which burned the bottom and ſides of the cork conſiderably, and occaſioned a good deal of ſmoke and flame to come out of the bottle. You will recollect, that I repeated this experiment in the preſence of yourſelf, Mr. ADAMS, and Mr. COVENTRY, when it ſucceeded perfectly; but the varniſh was this time ſo far burnt, that the braſs filings, which by by the combuſtion had changed their colour, were almoſt all dropped to the bottom of the phial.

I ſhall conclude this paper with the deſcription of a pocket electrometer which I have lately conſtructed, and which, on ſeveral accounts, ſeems preferable to thoſe of the moſt ſenſible ſort now in uſe. The caſe and handle of the electrometer is formed by a glaſs tube about three inches long, and three-tenths of an inch in diameter; half of which is covered with ſealing-wax. From one extremity of this tube, that is, that without ſealing-wax, a ſmall loop of ſilk proceeds, which ſerves occaſionally to hang the electrometer on a pin, &c. To the other extremity of the tube, a cork is adapted, which, being cut tapering on both ends, can fit the mouth of the tube with either extremity. From one extremity of this cork two threads proceed, a little ſhorter than the length of the tube, ſuſpending each a little cone of pith of elder. When this electrometer is to be uſed, that end of the cork which is oppoſite to the threads is puſhed into the mouth of the tube, then the tube forms the inſulated handle of the pith electrometer, as appears in fig. 1. When the electrometer is to be carried in the pocket, then the threads are put into the tube, and the cork ſtops it, as is repreſented in fig. 2. The peculiar advantages

advantages of this electrometer are, its convenient ſmall ſize, its great ſenſibility, and its continuing longer in good order than any other I have yet ſeen, as you have yourſelf experienced(d). To preſerve this electrometer from injury, it ſhould be carried in a tooth-pick caſe, or ſome other of the like ſort.

(*d*) I have lately conſtructed a portable electrometer of another kind, which is contrived ſo as not to be affected by the wind or the rain, and conſequently is very convenient to examine the electricity of the clouds out of doors in time of thunder-ſtorms: but I ſhall take another opportunity to preſent to the Royal Society a particular deſcription of the ſame.

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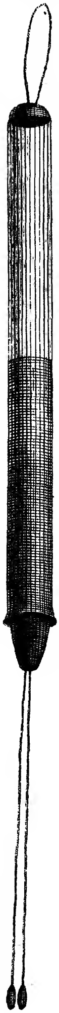

Fig: 1.

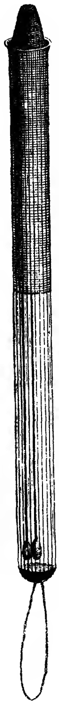

Fig: 2.